Proposed Competing Experiments at CERN

As requested in the letter from Mike Witherell, dated Jul 21,2000, we present here a discussion on the proposed competing experiments at CERN, namely HARP and NA49, their physics reach and schedules.

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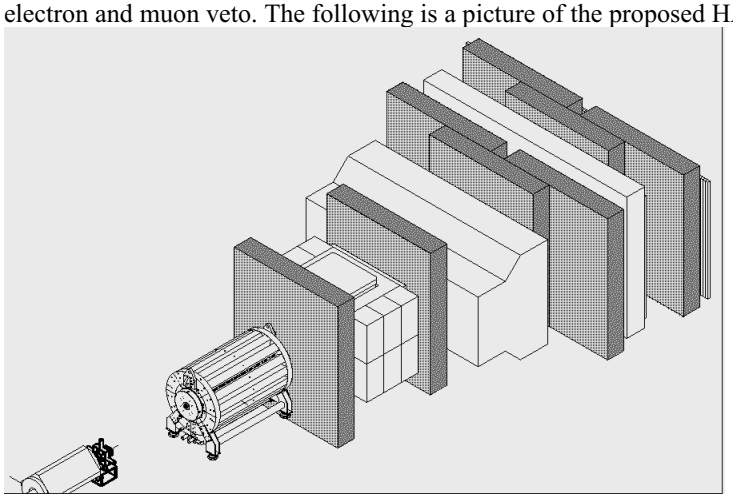
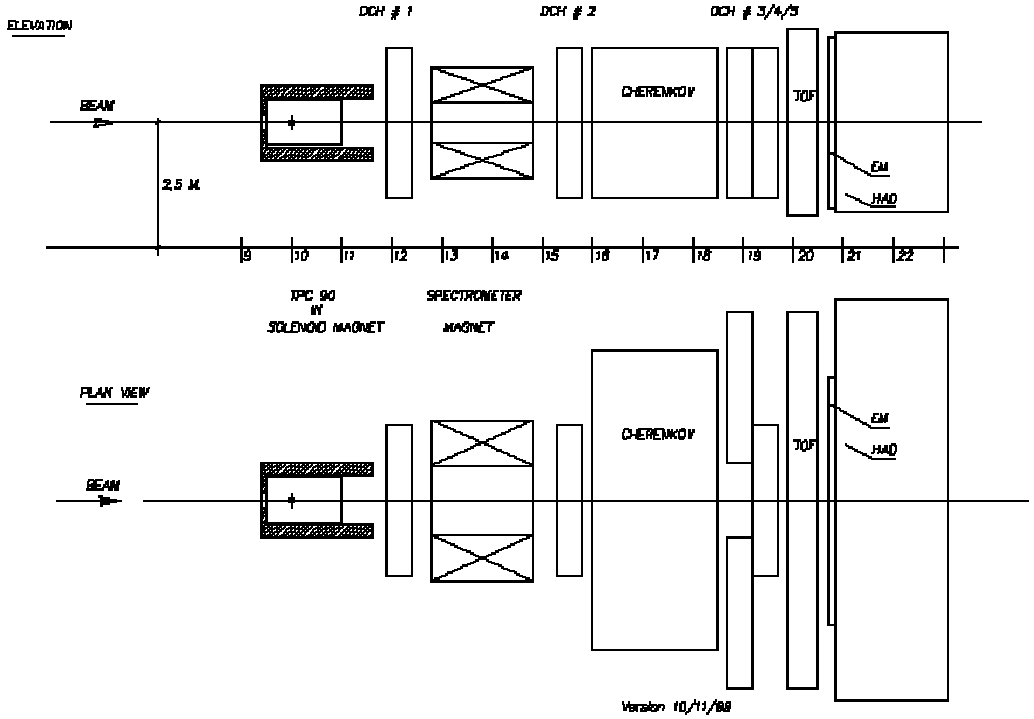
Preamble

P-907 started as a proposal during the Workshop on Fixed target Physics at the Main Injector held at Fermilab, May 1-4, 1997. We made our first presentation to the PAC as an expression of interest (EOI) in July 1997. The purposes of P-907 were to measure particle fluxes for Muon Colliders, test scaling laws of hadronic production and to measure nuclear cross sections. This was followed by submission of a proposal in April 1998 as a result of which we received encouragement to acquire the Bevalac TPC after its use in E910 at Brookhaven. The PAC asked for a new proposal for presentation at the May 1999 meeting. We received a letter from Mike Witherell, the new Fermilab director on July 6,1999 which encouraged us to proceed and present a more detailed proposal to the PAC in June 2000. The PAC deferred its final decision on P907 to November 2000.

The HARP experiment at CERN

There was a workshop on Neutrino factories organized at Lyon, France 5-9 July 1999. The HARP letter of intent was generated at that meeting in order to measure particle production cross sections on various targets from a 2 GeV proton beam for the purpose of investigating the efficacy of this method of generating an intense neutrino beam in a muon storage ring. The experiment was sited at the CERN PS, hence the name HARP (Hadron Production Experiment at the PS). The maximum energy of the primary proton beam on target is restricted to 15 GeV, set by the PS. HARP proposed to use a prototype of the ALEPH TPC with a solenoidal field . The tracks in the TPC drift along the direction of the beam. This enables HARP to detect wide angle and backward going tracks from the target when using low energy proton beams. Particle identification is provided by dE/dx in the TPC, a threshold Cerenkov counter, time of flight and an electron and muon veto. The following is a picture of the proposed HARP setup.





Schedule

The HARP experiment won rapid CERN approval and is now in a Technical Run from 25 Sep-25 October 2000. They are testing the PS Beam, Magnets, Target, Hodoscopes, Chambers and TOF system. They plan to have their physics run in 2001, once the TPC electronics have been built. They would in all likelihood continue to run in 2002.

Physics Goals

The HARP experiment plans to measure particle production off hydrogen, and various nuclear targets. They plan to use secondary proton and pion beams. Due to the low energy of the primary PS beam, their ability to do kaon and antiproton beams is limited. The measurements are motivated by neutrino factory needs as well as to understand the production of atmospheric neutrinos in cosmic ray interactions by measuring production cross sections off nitrogen and oxygen. This measurement needs to be continued to energies higher than what HARP is capable of and motivates a HARP3 phase of continuing these measurements at the CERN SPS using the existing NA49 apparatus. It should be pointed out that P-907 is capable of doing the atmospheric neutrino measurements over the entire energy range.

Particle ID, acceptances, rates

The TPC is capable of measuring particle ID using dE/dX in much the same way as P-907. However, the ability of HARP TPC to measure forward going tracks is limited due to the fact that the TPC drift is in the

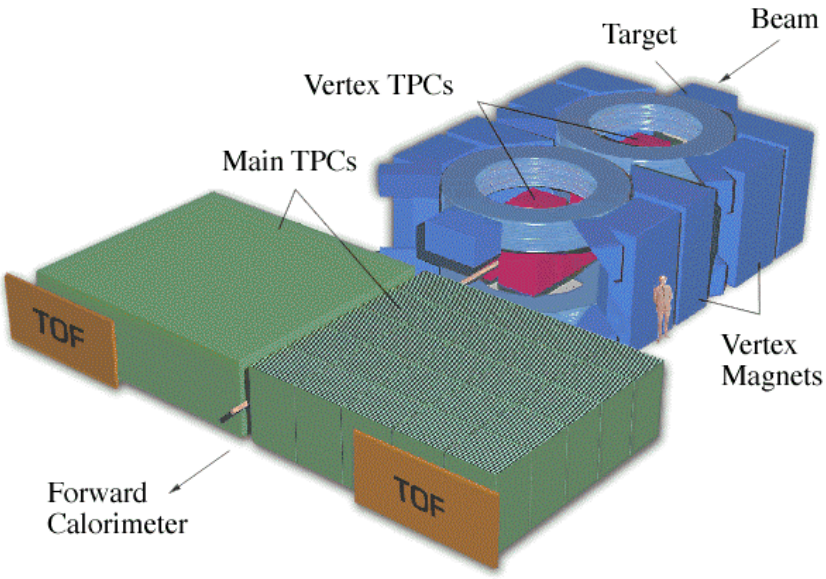
same direction as the beam. The HARP TPC therefore cannot be used in a high energy (~120GeV/c) beam measurement. Hence the need to go to NA49. The particle id is complemented by TOF as well as multi-cell Cerenkov detectors very similar to P-907. These do an adequate job covering HARP phase space.

The beam spill at the PS is 400ms every 14.4 seconds. HARP tries to overcome this by increasing their DAQ rates so that they sample 6000 interactions per spill using 3E5 particles on a 2% target. The drift time across the TPC is 30 μs whereas P-907 has a 16 μs drift time.

HARP thus has the ability and the data acquisition rate to make measurements in the 2GeV/c-15GeV/c momentum range that will overlap with P-907's abilities for pion and proton beams. It does not compete with P-907 for antiproton and kaon physics.

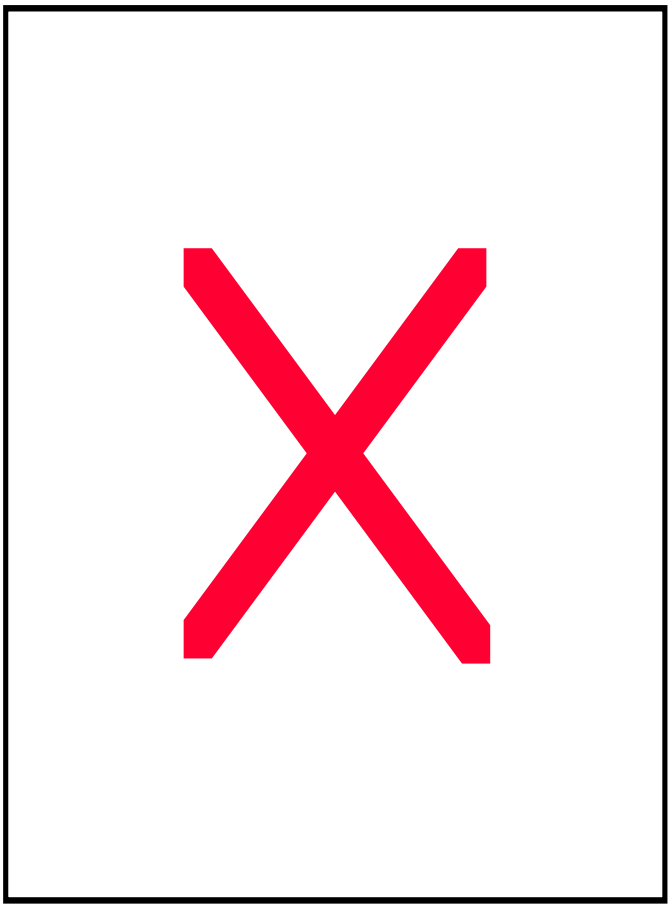
The NA49 experiment at CERN

Experimental Setup



The above picture shows the NA49 setup at the CERN SPS. The initial purpose of NA49 was to study heavy nucleus-heavy nucleus (e.g. Pb-Pb) collisions. It is an experiment designed to sample a large number (~2000) of tracks per event. Due to the high density of particles in the beam region, the TPC's are split along the middle, providing a dead region where forward physics is of importance. For doing a MINOS type measurement, one will have to bring the two TPC's together and move them to the side in order to recover some of the lost acceptance. The TPC walls will still present dead regions even if moved somewhat to the side.

Particle Id is by dE/dX in the TPC's and TOF . For fast tracks (<12GeV/c) relativistic rise of dE/dx is used to tell apart pions, kaons and protons. A typical particle id separation curve for tracks 9-11 GeV/c in momentum is shown below (taken from "The NA49 Large Acceptance Hadron detector" CERN-EP/99-001, 6-Jan-99). Notice the closeness of the proton and kaon peaks, which becomes worse as momentum increases.



Schedule

In a document entitled "Addendum-5 to Proposal CERN/SPSLC/P264", the NA49 experiment proposes to extend their studies of pA interactions in the year 2001 and beyond. Their total beam request is 4 weeks of SPS running a year devoted to pp and pA physics. The SPSC committee is to decide on this request at their next meeting 31Oct-1Nov 2000.

There may also be a request by a joint group of subsets of the HARP and NA49 collaborations to resurrect NA49 for a two month run in 2002 or 2003 after HARP has finished its data taking. The primary purpose of this is to extend the HARP atmospheric neutrino measurements to higher energies. MINOS target measurements may also be a goal.

P-907 capabilities vs NA49

The data acquisition rate of NA49 as currently configured is 32 events every 14.4 seconds, i.e. 2.2 Hz on average. MINOS needs 10^7 events per target. P907 proposes to measure the low energy and medium energy MINOS targets. At the projected P-907 data acquisition rate of 60Hz and allowing for the Main Injector duty factor (1sec spill every 3 sec) and a factor of 3 loss (1 year =10^7seconds), we expect to do 1 MINOS target in 7.1 weeks. The same target will take 65 weeks at this DAQ rate. There are possibilities to increase the data acquisition rate, one which costs 300K SF ,2 man years and will result in a 30-40% improvement in DAQ rate. The second proposal is a more involved job, that costs 1.44M SF, 4 .5 man years and rebuilding the DAQ system using STAR TPC readout. This is projected to yield a factor of "about 10" in DAQ speed. The document "Addendum-6 to Proposal CERN/SPSLC/P264", dated Aug 2000 discusses both these options and concludes (for the first option) "the total cost of 300K SF amounts to twice the yearly running budget of the collaboration, not to mention the inherent risks of a technically critical manipulation of existing processor boards including clock and control distribution lines whose reliability can only be judged once the full system data transfer integrity is tested".
For the more expensive second option, the same document concludes "The price tag of this system is completely out of range with the present financial commitments of the institutes and groups participating in the collaboration." It further states "In addition to the upgrade of the TPC readout system proper, also the auxiliary systems using CAMAC and FASTBUS would have to be completely revised to comply with the reduced dead time per event. In conclusion, we do not envision, given the actual strength and financial possibilities of the collaboration, to proceed with a DAQ upgrade."

For the MINOS measurements, it is important to match the emittance of the beam particle incident on the mm wide targets to the emittance of the actual proton beam. This is possible in P-907 since we plan to use a primary 120GEV/c main Injector proton beam for the MINOS measurements. It is much harder in NA49, since the 120 GeV/c proton beam is a secondary beam with large emittance and momentum spread, derived from a primary 400 GeV SPS proton beam.

As regards particle identification, P-907's abilities are superior, since we have a RICH in the forward direction that yields exceptional pi/K/p separation for particles > 12 GeV.
To conclude, the MINOS target measurements will be better done, faster and with better feedback to the experimentalists, if done at Fermilab using P-907. The same holds true for the study of hadron nucleus interactions for beam momenta up to 120 GeV.